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A Model for Determining the Maneuvering Space Requirements for Tractor-Trailers at Loading Docks

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A Model for Determining the Maneuvering Space Requirements for Tractor-Trailers at Loading Docks

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Abstract

In the planning of a modern food distribution center, the primary goal is to design a site and facilities complex that is efficient in daily operation and cost effective over the expected life cycle of those facilities. To optimize the efficiency of operation, it must be recognized that the single most important function of the center is to move product—overall efficiency is thus measured by the rate of product turnover. To that end, careful consideration must be given to the flow of work activities of the business enterprises, first, as individually functional units comprising a facility, and, second, as groups of facilities arranged on a composite site. With this approach, the planning process is most likely to be successful.

General Discussion

To facilitate the efficient movement of product through individual business enterprises, we must first provide for unrestricted corridor traffic flow on and around the distribution center site. Second, and just as important, we must provide adequate access and ease of maneuvering around the loading platform areas.

As the role of rail shipping has diminished in recent years and continues to do so, the trucking industry has steadily increased its share of bulk annual shipping tonnage. Therefore, an understanding of the type and size of tractor-trailer combinations that are most likely to serve the center is essential to the planning process.

As individual State laws and regulations change to keep pace with the development of the truck shipping industry, we are also seeing equipment dimension and specification changes among the different manufacturers—changes that directly influence the planning process.

To appreciate the impact of various combinations of tractor-trailer dimensions on space planning, let us consider some of the more critical of those dimensions. For example, trailer lengths and widths often vary with the needs of individual shippers. Trailer manufacturers design and build their equipment in accordance with the specifications provided by the carrier, as long as they comply with applicable State and Federal regulations and safety requirements.

Currently, most States restrict the overall length of tractor-trailer combinations. In 1990, 26 percent of the trailers in use in the United States did not exceed 53 feet in length. Two States allow a maximum trailer length of 57 feet.

The Truck Trailer Manufacturers Association, along with individual tractor and trailer manufacturers, predicts that by the year 2000, at least half the trailers on the road in the United States will be 53 feet in length, with an overall length of tractor-trailer combination varying between 65 and 75 feet. These dimensional changes will, of course, affect the planning and design of any food distribution center facilities.

Unfortunately, there does not appear to be a current standard for dimensions governing maneuvering space requirements for the myriad tractor-trailer combinations available. Considering the diversity of the trucking industry, compilation of such a standard would be a tedious undertaking and, consequently, would in all probability be short-lived in its accuracy. It is in this light that we will demonstrate a general graphical method of analysis for these space requirements—a planning tool at best—that can be comfortably used in the conceptual and preliminary planning stages of your projects. More detailed specific criteria will, therefore, be considered to be beyond the scope of this discussion.

Figure 1 illustrates the variability of some of the important trailer dimensions that directly influence the determination of space requirements. These variables will also affect the results of the graphical method of analysis that we will discuss later.

The publication ***Truck Trailer Docks***, last published in 1979 by the Truck Trailer Manufacturers Association, Inc. (no longer in print), presented a graphical method of analysis for determining the "Minimum Interference Distance," or the space required for maneuvering a tractor-trailer to and from a loading platform. The same principles of graphical analysis are used herein to provide a means of determining this minimum distance for some of today's larger tractor-trailer combinations.

For this graphical method of analysis, a number of simplifying assumptions were made which tend to influence the results slightly; thus, these same results will differ from those which occur in actuality.

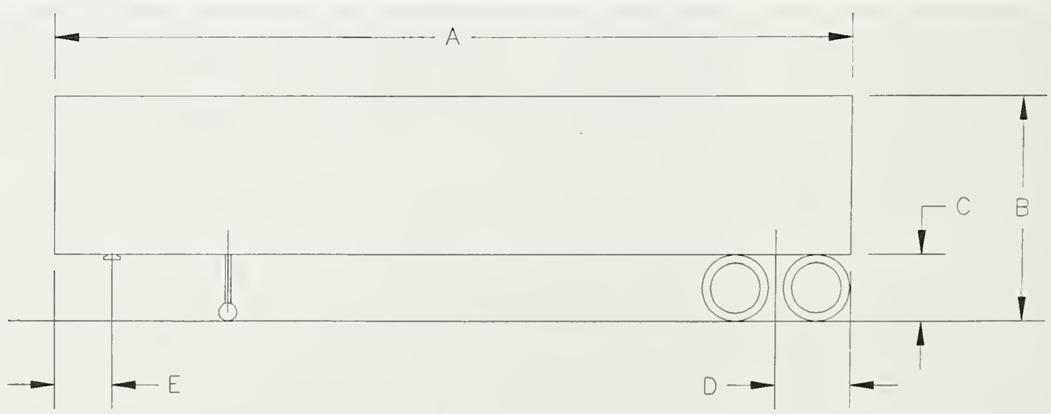
The maneuvering space required for a large tractor-trailer mainly depends on the following variables:

- The overall length and width of the tractor-trailer combination.
- The center-to-center spacing between adjacently parked tractor-trailers.
- The turning radius of the truck tractor pulling the combination unit.
- The axle spacing of the truck tractor (distance between the front axle and rear single or tandem axle).
- The distance from the kingpin to the trailer axle or center of tandem.

The trailer dimensions used for determining the required horizontal maneuvering space and the vertical clearances were shown in *figure 1*.

As an example, *figure 2* illustrates the application of the graphical method for determining the **"Minimum Interference Space"** required for a specific tractor-trailer combination to move about the site unobstructed. For purposes of this example problem, we will consider a tractor-trailer combination with the following typical dimensional characteristics:

- Overall length = 65 feet
- Trailer length = 53 feet



A. Overall Length of Trailer = 40'–57'

B. Overall Height of Trailer = 13'–6" – 14'–0"

C. Floor Height = 4'–0" – 4'–6"

D. C/L Tandem Assembly to Rear End = 4'–6" – 11'–6"

E. Front to C/L Kingpin = 3'–0" – 4'–0"

* Overall Width of Trailer = 8'–0" – 8'–6"

TYPICAL TRAILER DIMENSIONS

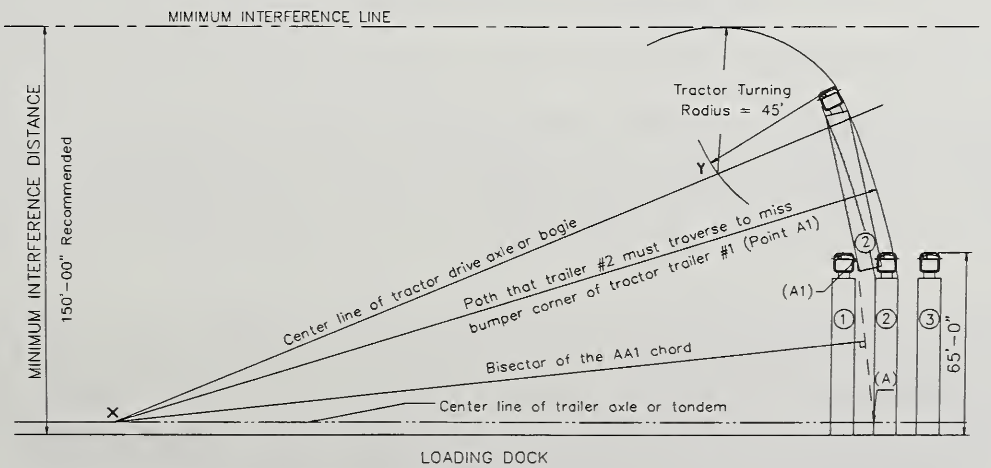
Figure 1

- Minimum turning radius for the tractor is 45 feet (to the outside edge of the front bumper).
- Width of the trailer = 8 1/2 feet

The items noted above represent the most common dimensions for tractor-trailers currently in use. The minimum turning radius is primarily based on the opinions of several tractor and trailer manufacturers consulted for this analysis.

Graphical Method of Analysis: Procedures

1. Pick a scale to be used in the problem.
2. Draw to scale trailers up against the loading dock at expected spacings. (Use longest and widest trailer measurements and closest parked spacings expected at dock).
3. Extend trailer #2 axle or tandem center line in direction of turn.
4. Draw chord AA1 from that point on the side of trailer #2 where the axle or tandem center line intersects the side of the trailer body to the bumper corner of the adjacent trailer #1. This is a chord of the curve through which point A (#2) must traverse to miss trailer #1.
5. Bisect chord AA1 and extend a perpendicular line until it intersects the extension of trailer #2 axle or tandem center line at point X. This is the point about which all points on trailer #2 must rotate to miss striking trailer #1.
6. With the compass point on point X, construct an arc from the furthest bumper corner of tractor #2 to represent its travel path as the trailer moves concurrently from point A to point A1. Sketch trailer #2 in its new position as shown.
7. Through the location of the kingpin, extend a line back through point X. This line then represents the center line of the tractor drive axle or bogie. From this drive axle center line, draw the tractor with the greatest turning radius in its proper position with respect to trailer #2 in its second position.
8. With the compass point on the tractor front bumper (opposite side from the direction of the turn), scribe an arc equal to the turning radius of the tractor so that it intersects the center line of the tractor drive axle at point Y.
9. With the compass set at the turning radius of the tractor, place the point at Y and scribe an arc that represents the curve about which the bumper will travel.



TURNING MOVEMENT FOR 65 FOOT TRACTOR TRAILER

Figure 2

RESULT: Measure the distance from the dock to that point on the curve just drawn which represents the greatest distance from the dock. THIS REPRESENTS THE ABSOLUTE MINIMUM DISTANCE AWAY FROM THE DOCK NEEDED FOR MANEUVERING AREA (based on a single continuous forward movement).

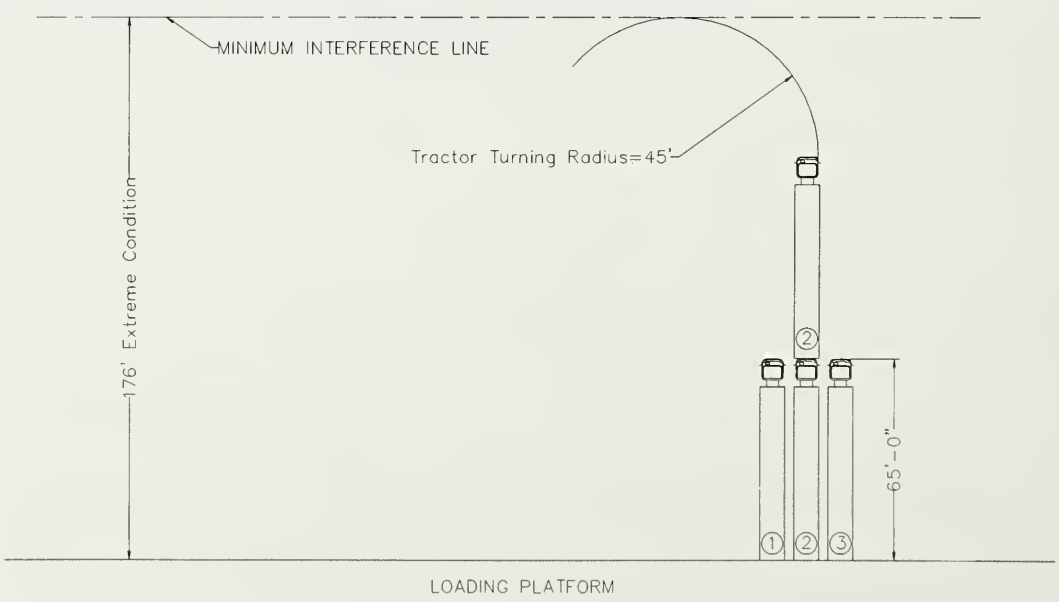
Referring to *figure 2*, the maneuvering truck #2 is initially parked between two other trucks #1 and #3 of the same size. The trucks are parked on a 15-foot center-to-center spacing, which allows for approximately 6 1/2 to 7 feet of clearance in between.

The results of the graphical analysis indicate that the Minimum Interference Distance required for turning a 65-foot-long tractor-trailer under the described conditions is 143 feet 6 inches ±. For practical considerations, we should also add a safety margin allowance to these findings, and thus a Minimum Interference Distance of 150 feet would be reccmmended for this example set of conditions.

Figure 3 represents an example of the most extreme of conditions that may be encountered as a result of absolute minimum clearances between the parked tractor-trailer combinations.

For this example, using trucks with the same parameters as in *figure 2*, the close spacing of the trucks prohibits a turn by trailer #2 until it has cleared the adjacent tractors. As a result, the Minimum Interference Distance has to be increased to 176 feet.

The Minimum Interference Distance, as illustrated in *figures 2* and *3*, is constant only for one single set of parameters. Any change in the tractor or trailer dimensions, spacing between parked vehicles, tractor characteristics, etc., will have a direct effect on the calculation of the Minimum Interference Distance.



EXTREME TURNING MOVEMENT CONDITION

Figure 3

Figure 4 illustrates the case of two loading platforms facing each other.

Depending on the property ownership or management arrangement for the facilities, the Minimum Interference Distance requirements for opposing docks can vary.

An example, as shown in *figure 4*, is where an individual ownership type of arrangement exists, whereby each business might own rights of exclusive use up to the right-of-way of the corridor circulation space. In this situation, the Minimum Interference Distance required between the docks must be increased considerably to allow for unencumbered movement of trucks into the common right-of-way area without overlapping of their paths of travel.

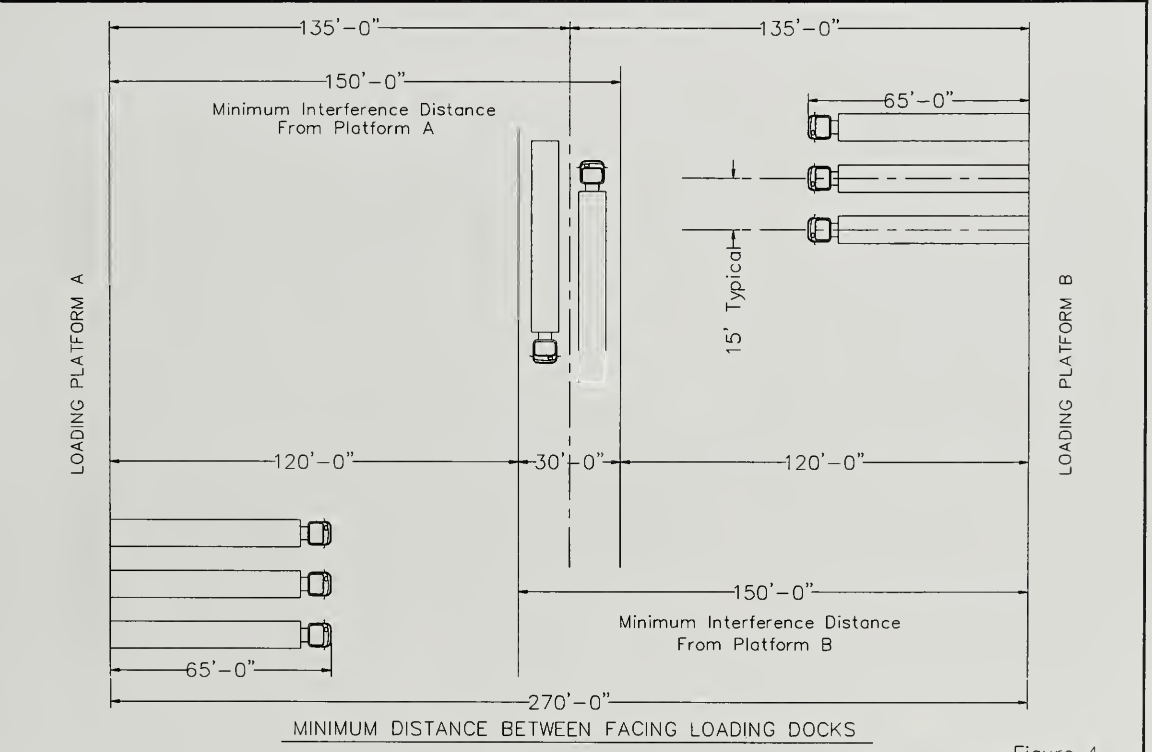


Figure 4

This would be in contrast to a case where all building facilities are commonly owned and managed by an Authority, and each business enterprise leases a unit or units along with the corresponding dock spaces. There, all tenants would then share equally in the use of the corridor circulation space, thus reducing the necessary net distance between the opposing docks.

The graphical method described earlier and illustrated in *figure 2*, represents a starting point for calculating an adequate distance between the two platforms. With safety and efficient operation of the facility in mind, the spacing of the platforms can be adjusted (increased or decreased) from the initial sum of the two Minimum Interference Distances (one for each platform) in order to satisfy other requirements of the facility (such as traffic flow projections, etc.).

In the example in *figure 4*, the initial distance of 150+150=300 feet was decreased by the width of the roadway (equal to 30 feet). That would make the distance between the two opposing loading platforms equal to 300-30, or 270 feet.

Summary

In summary, if we merely reflect on the magnitude of change that has occurred in the trucking industry to date, we can conclude with reasonable certainty that it will continue to change as truck capacities increase. Distribution center planners and designers must make the best use of the available tools, such as this graphical method of analysis, to try to forecast these changes and make accommodations for them during the planning stages. Only in this way can those distribution centers planned today continue to serve the agricultural industries of tomorrow.